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DETERMINATION OF POLYPLOIDY FROM HERBARIUM SPECIMENS

Robert P. Celarier and K. L. Mehra

In the evolutionary history of the flowering plants there are several biological phenomena known to be of major consequence. Foremost among these, and perhaps the best understood, is polyploidy. A brief survey of any of the recent compilations of chromosome numbers of the Angiosperms (Löve and Löve, 1948, Delay, 1951; Darlington and Wylie, 1955) will suffice to show the frequency of this phenomenon. There are literally hundreds of examples of so called intraspecific polyploids reported, not to mention the even more frequent condition of interspecific polyploidy.

The importance of polyploidy in the critical evolutionary fields of taxonomy, geobotany, hybridization, mode of reproduction, etc. has been shown and discussed by many workers (Löve, 1951; Löve and Löve, 1949; Gustafsson, 1947; 1948; Muntzing, 1936; Stebbins, 1940; 1950; Darlington, 1956, etc.). Not only is the importance of polyploidy well known but much is understood concerning its biological mechanisms of operation.

Because of the obvious significance of polyploidy in both continuous and discontinuous variation of plants, it is a factor that cannot easily be dismissed in any detailed study involving the relationships of species or their modes of origin.

Determination of chromosome numbers is, however, a time consuming operation, and becomes virtually impossible for monographers who deal principally with non-living herbarium materials. Some effort has been made to overcome this handicap and recently Khoshoo (1955) has been able to study chromosomes

from herbarium material in *Impatiens*. However the techniques are rather laborious, the results far from the best, and the extent to which the technique is applicable is not yet known.

Numerous studies have been conducted that attempt to correlate morphological conditions with degree of ploidy (see Stebbins, 1950 for review), and some workers believe that there is almost always some correlation (Löve, 1951). Although the general conclusion from these studies is that there are no universal criteria, nevertheless there are certain characters that have rather general application. Foremost among these is cell size.

From herbarium material there are usually easily available two types of cells (pollen grains and guard cells of the stomata). Since there is often some overlapping between cell size and degree of ploidy, it is desirable, and sometimes essential, to study the cell size of both before drawing conclusions.

In general, pollen grains are easily studied, but the conventional method for studying guard cells requires a pretreatment of the leaf, followed by scraping or stripping (deWet, 1954). In any event some portion of the specimen is mutilated or destroyed, a condition that is very undesirable especially with valuable specimens such as types.

In this report an impression method is described for the study of the guard cells of the stomata that is quick, reliable, and causes no damage to the specimen. This method is based on the principles of impression long used in paleontology, and with the use of some of the modern plastics gives very desirable results. Somewhat similar methods have been used by plant pathologists (Long & Clements, 1934; Husain, 1956) to detect the open or closed condition of the stomata.

The procedure is simply to mix cellulose nitrate[1] in acetone until a viscous solution is obtained. When the constancy of the solution is such that it spreads smoothly with a camels hair brush, paint the surface of the leaf to be studied with the solution. This will work better if the leaf surface has been previously cleaned with acetone. The solution is allowed to dry thoroughly and is then peeled off with tweezers. This plastic strip is then

[1] Jacobo Ortega Castro of this department, in a study involving the relationship between the opening and closing of the stomata in wheat and leaf rust infection, has used cellulose acetate and collodion with equal success. His work shows that at different temperatures different plastics are preferable.

floated in a drop of water on a slide, covered with a cover slip, and is ready for study under the microscope.

Cell impressions prepared by this method are usually distinct (figs. 1–8) and measurements can be made with considerable confidence.

RESULTS

In the present study several grass species complexes of the tribe *Andropogoneae* were analyzed. A rather detailed study was made of the *Dichanthium annulatum* complex, which included diploids ($2n = 20$), tetraploids ($2n = 40$), and hexaploids ($2n = 60$). Also studied, but in less detail, were tetraploids, pentaploids, and hexaploids of the *Bothriochloa ischaemum* complex, and tetraploids and hexaploids of the *B. intermedia* and *B. pertusa* complexes. The chromosome numbers of all accessions used in this study were previously determined (Celarier, 1957; Celarier and Harlan, 1955; Celarier, Mehra, and Wulf, in press, and unpublished).

Pollen grains and stomata guard cells were studied from both fresh material and herbarium specimens and the results are given in tables 1 and 2. Although most specimens were only three or four years old, it seems likely that, under proper storage conditions, only a negligible amount of change would be expected with the age of the specimen.

D. ANNULATUM COMPLEX

In the present report three diploid, eight tetraploid, and two hexaploid accessions were studied. The data are presented in table 1, and figures 1–8 show their general appearance.

Pollen grain size was quite variable in all accessions with a range of approximately 10μ. However the means were similar in all accessions of one ploidy level, and quite different between polyploids (figs. 1–3). The diploids means ranged from 32.0 to 33.0μ, the tetraploids from 36.2 to 39.9μ, and the hexaploids from 42.9 to 48.7μ. Pollen grains from herbarium specimens were almost always smaller than fresh material but usually the mean values were of less than one micron difference.

There was also variation in stomata guard cell size but it was much less than in pollen grains and was in general, less than five microns. Again the mean values were quite distinct at the different ploidy levels. In the fresh material the means in the diploids varied from 23.7 to 24.8μ, in the tetraploids from 30.0 to 32.0μ, and the hexaploids varied from 36.8 to 45.9μ. The same kind of variation was seen in the herbarium specimens but guard cells were in all cases considerably smaller than in fresh material (figs. 4–6).

TABLE 1. Comparison of pollen grains and guard cells with degree of ploidy in *Dichanthium annulatum*.

A-No.	Location	2n	Pollen Grain Size—μ				Guard Cell Size—μ			
			Fresh		Specimens		Fresh		Specimens	
			range	mean	range	mean	range	mean	range	mean
3242	Calcutta, India	20	26.5–37.1	32.4	26.5–37.1	32.2	22.8–25.2	24.3	10.8–16.8	13.6
3965b	Calcutta, India	20	29.1–37.1	32.9	29.1–37.1	32.8	22.8–26.4	24.8	13.2–15.6	14.0
5396	Belatal, India	20	26.5–37.1	33.0	26.5–37.1	33.2	21.6–25.2	23.7	12.0–16.8	14.6
5437	Lucknow, India	40	31.8–47.7	39.0	31.8–42.4	38.6	30.0–32.4	31.0	18.0–22.8	20.6
5797	Bombay, India	40	31.8–42.4	36.3	31.8–42.4	36.3	28.8–33.6	31.8	22.8–26.4	24.1
4600	Lucknow, India	40	31.8–42.4	36.2	31.8–42.4	36.3	27.6–32.4	30.0	19.2–24.0	20.9
3789	Giza, Egypt	40	31.8–42.4	37.9	31.8–42.4	37.2	28.8–33.6	30.7	18.0–24.0	21.0
4082	South Texas (Int.)	40	37.3–42.4	39.3	31.8–42.4	38.6	30.0–34.8	31.4	18.0–22.8	20.3
4099	Punjab, India	40	37.1–45.0	39.9	37.1–45.0	39.4	28.8–36.0	32.0	18.0–20.4	19.6
3182	N. Gallilea, Israel	40	31.8–42.4	37.1	31.8–42.4	36.4	30.0–33.6	31.7	20.4–27.6	22.4
5295	Coimbatore, India	40	31.8–42.4	37.1	31.8–42.4	36.4	28.8–32.4	30.4	16.8–20.4	18.8
3716	Southern Rhodesia	60	31.8–53.0	48.7	37.1–47.7	45.1	34.8–38.4	36.8	26.4–34.8	29.6
4080	South Africa	60	37.1–53.0	42.9	39.7–47.7	43.8	43.2–48.0	45.9	24.0–30.0	26.2

TABLE 2. Comparison of pollen grains and guard cells with degree of ploidy in *Bothriochloa* species.

A-No.	Location	2n	Pollen Grain Size—μ Fresh range	Pollen Grain Size—μ Fresh mean	Pollen Grain Size—μ Specimens range	Pollen Grain Size—μ Specimens mean	Guard Cell Size—μ Fresh range	Guard Cell Size—μ Fresh mean	Guard Cell Size—μ Specimens range	Guard Cell Size—μ Specimens mean
	Bothriochloa ischaemum									
561	Mus, Turkey	40	31.8–42.4	37.1	31.8–39.7	35.4	24.0–26.4	25.0	15.6–20.4	19.0
5704	Peking, China	40	31.8–42.4	36.7	34.4–42.4	36.6	27.6–30.0	28.7	15.6–20.4	18.0
726	Amoy, China	50	34.4–47.7	38.2	31.8–45.0	39.3	28.8–31.2	30.2	19.2–22.8	21.3
6459	Hong Kong, China	50	31.8–45.0	37.8	31.8–39.7	35.5	27.6–32.4	29.0	18.0–21.6	20.6
2582	Formosa	60	37.1–47.7	43.9	37.1–47.7	43.9	28.8–32.4	30.7	19.2–24.0	21.8
1347	Triangle City, China	60	37.1–47.7	41.9	37.1–45.0	40.9	31.2–36.0	31.8	18.0–24.0	22.0
	Bothriochloa intermedia									
5409	Bareilly, India	40	31.8–39.7	34.7	31.8–37.1	34.4	24.0–27.6	25.8	14.4–16.8	15.2
5450	Delhi, India	40	31.8–42.4	36.9	31.8–39.7	35.0	22.8–28.8	25.5	13.2–15.6	14.7
4596	Gatton, Australia	60	34.4–47.7	42.0	34.4–47.7	41.9	25.2–31.2	29.1	18.0–21.6	19.6
4597	Gatton, Australia	60	31.8–47.7	39.7	31.8–42.4	39.7	30.0–36.0	32.8	18.0–21.6	20.1
	Bothriochloa pertusa									
4806	Hyderabad, India	40	31.8–39.7	35.8	31.8–37.1	35.0	24.0–27.6	25.8	12.0–15.6	13.9
3185	Cuba (Int.)	40	34.4–42.4	37.6	31.8–42.4	36.5	21.6–27.6	24.3	13.2–15.6	14.2
4905	South Africa	60	31.8–45.0	39.4	31.8–42.4	37.1	28.8–32.4	30.0	18.0–21.6	20.2
3704	South Africa	60	39.7–47.7	44.3	37.1–47.7	42.2	34.8–38.4	34.9	20.4–22.8	21 6

Although the diploids, tetraploids, and hexaploids could be easily distinguished from one another in the herbarium materials it is obvious that comparisons between herbarium and fresh materials cannot be made until a correction factor is established.

B. ischaemum complex

Two accessions each were studied in the tetraploids, pentaploids and hexaploids (table 2). As in *D. annulatum* there is considerable variation in pollen grain size (ca. 10–15μ) whereas the range in variation in the guard cells is small (less than 5μ). The means however were rather constant for both, but different in different ploidy levels.

In the tetraploids the means of pollen grain size ranged from 36.7 to 37.1μ for fresh materials and 35.4 to 36.6μ for specimens. The pentaploids ranged from 37.8 to 38.2μ for fresh materials and 35.5 to 39.3μ for specimens, and in the hexaploids the range was 41.9 to 43.9μ for fresh material and 40.9 to 43.9μ from specimens.

Stomata guard cells were also distinct but as in *D. annulatum* showed a big difference from fresh material to specimens.

In the tetraploids the means ranged from 25.0 to 28.7μ in fresh materials and 18.0 to 19.0μ in specimens. The pentaploids ranged from 29.0 to 30.2μ in fresh materials and 20.6 to 21.3μ in specimens, and the hexaploids ranged from 30.7 to 31.8μ in fresh material and 21.8 to 22.0μ in specimens.

In *B. ischaemum* it seems that pentaploids cannot be easily separated from hexaploids on guard cell size alone but by the use of both pollen grain and stomata guard cells the separation is fairly reliable.

B. intermedia complex

In this species only two tetraploids and two hexaploids were used. The tetraploids were readily distinguishable from the hexaploids with both pollen grain size and stomata guard cell size. Variation in both was rather similar to that seen in *D. annulatum* and *B. ischaemum*.

The tetraploids had a range in mean pollen grain size of 34.7 to 36.9μ in fresh materials and 34.4 to 35.0μ in specimens; whereas the hexaploids ranged from 39.7 to 42.0μ in fresh material and 39.7 to 41.9μ in specimens.

The range of the means in guard cell size were 25.5 to 25.8μ in fresh materials and 14.7 to 15.2μ in specimens for the tetraploids and for the hexaploids were from 29.1 to 32.8μ for fresh materials and 19.6 to 20.1μ for specimens.

B. pertusa complex

In this species complex two tetraploids and two hexaploids were used and the results were similar to those found in the other species.

The range in pollen grain means was 35.8 to 37.6μ for fresh material

Figs. 1–8. Pollen grains and stomata guard cells in *Dichanthium annulatum*. Figs. 1–3. Pollen of the three ploidy levels. X300. Fig. 1 diploid. Fig. 2 tetraploid. Fig. 3 hexaploid. Figs. 4–6. Comparison of stomata guard cells from fresh mounts and plastic peels of herbarium specimens in the three ploidy levels. X1350. Fig. 4 diploid. a. fresh material. b. plastic peel of specimen. Fig. 5 tetraploid. a. fresh material. b. plastic peel of specimen. Fig. 6. hexaploid. a. fresh material. b. plastic peel of specimen. Figs. 7–8. Comparison of plastic peel of fresh material (Fig. 7) with plastic peel of specimen (Fig. 8) in the hexaploid. X300.

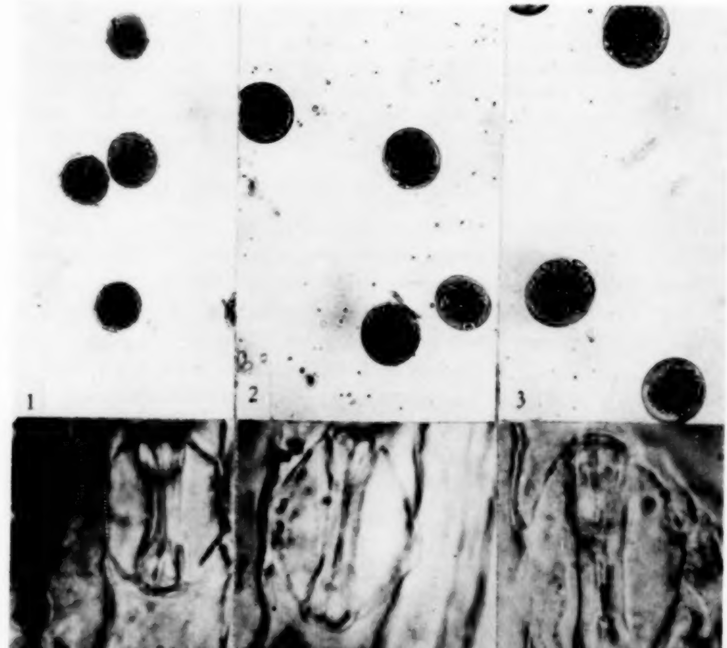

Fig. 1–8. For explanation see opposite page.

and 35.0 to 36.5μ for specimens in the tetraploids, and 39.4 to 44.3μ for fresh material and 37.1 to 42.2μ for specimens in the hexaploids.

The stomata guard cell size was also distinct with means ranging from 24.3 to 25.8μ in fresh material and 13.9 to 14.2μ in specimens for the tetraploids; whereas, the hexaploids ranged from 30.0 to 34.9μ in fresh material and 20.2 to 21.6μ in specimens.

Discussion and Conclusions

It has been shown that both pollen grain and stomata guard cell size are fairly reliable indicators of the degree of ploidy in several of the Old World species of the genera *Bothriochloa* and *Dichanthium*. It has also been shown by Gould (1957) that pollen grain size is useful in determining the degree of ploidy in several of the American species of *Bothriochloa*.

In the species studied there was no difficulty in distinguishing between diploids, tetraploids and hexaploids. However in *B. ischaemum* the differences between the pentaploids and hexaploids were not so distinct, but by the use of both pollen grain and guard cell sizes a fairly reliable conclusion could be drawn.

In general it was possible to place the materials studied in their proper ploidy levels by pollen grain and guard cell size regardless of the species involved. However there were exceptions to this, such as the tetraploid *D. annulatum* A-4099 with pollen grains 39.9μ and guard cells of 32.0μ and the hexaploid *B. intermedia* A-4597 with pollen grains of 39.7μ and guard cells of 32.8μ.

The impression technique for measuring guard cells is shown to be quite reliable but the actual measurements were in all cases much less than those made from fresh material. In order to determine what portion of this decrease in length was due to the technique and what portion was due to the drying of the specimens, measurements were also made from plastic strips taken from fresh material.

In the diploid *D. annulatum* A-3242 the mean guard cell measurements from fresh material was 24.3μ whereas the plastic strip measurements from specimens was 13.6μ. Plastic strip measurements of fresh material of this accession were found to be 20.4μ. From this it is seen that a considerable portion of this decrease in size is due to the technique itself but that most of it is probably due to the shrinkage in drying of the specimens. A similar condition was found in the hexaploid (figs. 7–8) but only a few measurements were made.

These studies seem to warrant certain recommendations in the procedures used in studies where it is desirable to determine chromosome numbers from herbarium specimens. The following appear to be significant:

1. Pollen grain and stomata guard cell size are usually reliable indicators of polyploidy, and the use of both would be expected to give much more dependable results than either alone.

2. Actual chromosome counts should be made from at least a few plants of several polyploid levels. Pollen grain and guard cell measurements from these plants can serve as a standard.

3. Data should be calculated in terms of ranges and means. This seems to be especially important in studies of pollen grains.

4. Guard cells from herbarium specimens can be reliably measured by the impression technique but when compared with fresh material a correction factor must be taken into account to offset the shrinkage.

5. Conclusions regarding chromosome number based on cell size should be transferred to a second species with extreme caution, unless some chromosome counts of the second species have been made so that a standard can be established.

6. Data concerning cell size would be a valuable addition to a monograph even if the chromosome numbers of the taxa involved are not known, in that they may offer a suggestion of polyploidy and will be available if cytological studies are made in the future.

Summary

Data are presented that demonstrate a correlation between the degree of polyploidy and size of pollen grains and stomata guard cells in four species complexes of the grass genera *Dichanthium* and *Bothriochloa*. These studies were made both from living material and dried herbarium specimens.

An impression technique using plastic strips is outlined for the study of stomata guard cells from herbarium specimens. This technique gives reliable measurements without damage to the specimens.

Some of the limitations to the use of cell size as a gauge of polyploidy are discussed and certain recommendations are offered based on present studies.—DEPARTMENT OF BOTANY AND PLANT PATHOLOGY, AGRIC. EXP. STA., OKLAHOMA STATE UNIVERSITY, STILLWATER.

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THE NAME LEPANTHES TURIALVAE: A SOURCE OF CONFUSION

Richard Evans Schultes

One of the most puzzling concepts in the orchid genus *Lepanthes* has been *L. turialvae* Rchb. fil., described from material collected in Costa Rica. The binomial has been applied to a bewildering array of species which obviously represent different concepts and has, as a result, become a rather convenient, albeit an inexact,

receptacle to which are referred many Middle American collections the identification of which might pose difficulties or doubts.

During my investigation of the species of *Lepanthes* known from Mexico, the name *Lepanthes turialvae*, with its present vague interpretation, continually confounded the study. Critical examination of what has been called *Lepanthes turialvae* in the literature and herbaria convinces me that, whichever of the several concepts is followed, it is not represented in Mexico. Nevertheless, it would seem advisable to present the following notes which have grown out of my study of *Lepanthes turialvae*, so that they may be made available to future workers in the genus.

Lepanthes turialvae Reichenbach fil. in Bonpl. 3 (1855) 225.

Original description: "*Lepanthes Turialvae* (*Effusae*): similis *L. cochleariformi* Sw. vaginis arctis, ostio tantum angusto microscopice muriculatis, folio ovato acuto bene limboso, racemi pectinati bracteis parvis muricatis, sepalo inferiori alte bifido, tepalis incisione triangula extrorsa acuta bilobis, labelli lobis obtuse triangulis. Stengel drei bis vier Zoll hoch mit Einschluss des zollangen Blatts. Blüthe nach Hrn. Dr. Oersted's zeichnung beschreiben. Sepalen dreieckig fleischroth. Tepala gelblich, obserseits mit Purpurroth auf Innenecke. Lippenlappen und Säule purpurroth. Turialva in Costarica, 3000′. Oersted."

In the same year, Reichenbach (Xen. Orch. 1 (1855) 151, 156, t. 50, fig. V, 15–16) published a second (Latin) and a third (German) description, differently worded but referring essentially to the same concept. In connection with these descriptions, he published drawings showing (V) a leaf (with its sheaths) and inflorescence (with one flower), (15) a flower and (16) a bract. Reichenbach intimated (loc. cit. 151) that the description was based upon Oersted's collection in the Copenhagen Herbarium ("Vid. sp. sicc. in herbario Hafniensi").

Through the kindness of Dr. O. Hagerup, director of this herbarium, we were able to borrow what is probably the type of *Lepanthes turialvae* and a water-color of the flower made by Oersted himself from the living plant in the field. The binomial "Lepanthes Turialvae Rchb." is written under the floral drawing in Reichenbach's own hand. There is no flower present on the specimen. Probably none was ever available to Reichenbach, for he stated clearly (Bonpl. 225) that his description of the flower was based on Oersted's drawing. Certainly, Reichenbach's rather inadequate sketches of the flower match very closely the Oersted water-color.

We have also, thanks to the cooperation of Dr. K. H. Rechinger, borrowed for study from the Reichenbach Herbarium in Vienna a sheet (No. 54553) on which there is a sterile specimen and a colored sketch of the flower. This sheet from Vienna is likewise labelled "Lepanthes Turialvae Rchb."

The sterile collection from Vienna is said to represent Oersted's collection made in Turrialba, Costa Rica, at 3,000 feet altitude. It is here, however, that confusion enters the picture. Neither the two detached leaves nor the sheaths covering the secondary stem represent, in my opinion, the same species as that which we have thought to be the type. But the colored sketch of the flower is identical with that in the Copenhagen material and, accordingly, corresponds to the floral diagram published by Reichenbach.

Reichenbach's original description of the sterile parts seems not to have been based on the suborbicular-ovate and apically tridentate leaf which is found in Copenhagen, but rather on the elliptic and very acute leaves attached to sheet No. 54553 from Vienna. His second description (Xen. Orch. 151) definitely refers to the Copenhagen material, for he stated that the leaf was "apice attenuato brevissimo tridentatum."

There is in the Reichenbach Herbarium a sheet (No. 54553) which Reichenbach himself labelled "*Lepanthes* Turialvae." The collection was made in Turrialba by Wendland: *Wendland 549*. This sheet has a habit sketch of the plant and a very careful drawing of the flower. Mr. Elmer W. Smith recently prepared a larger drawing from a flower taken from this collection, boiled and floated out in water; his drawing agrees in all essentials with Reichenbach's. In *Wendland 549*, the anterior lobe of the petals is triangular, the posterior obliquely subquadrate; whereas the petals shown in the type-drawing of the flower of *Lepanthes turialvae* have both lobes elliptic-lanceolate. The petal-lobes in the former are not spreading and, consequently, have no sinus between them; those of the latter are shown as very spreading with a conspicuous sinus.

Reichenbach not only annotated *Wendland 549* as *Lepanthes turialvae*. In an article treating of the orchids collected by Oersted, he (Beiträge zu einer Orchideenkunde Central Americas (1866) 57, 90, t. 10, figs. III, 16) illustrated as *Lepanthes turialvae* what is obviously the orchid represented in the collection *Wendland 549*. This illustration is wholly distinct from that published in *Xenia Orchidacea* eleven years earlier.

In view of 1) the apparent discrepancy in sterile parts between the Copenhagen and the Vienna material collected by Oersted, both of which Reichenbach considered to represent *Lepanthes turialvae* and 2) his identification of *Wendland 549* as *L. turialvae*, we must agree that Reichenbach himself had either an extremely vague or else a confused conception of the morphological characters on which *L. turialvae* was based.

An examination of the Middle American material labelled *Lepanthes turialvae* in the Orchid Herbarium of Oakes Ames indicates the extent of the confusion attendant upon the use of this binomial, for there are clearly several concepts involved which only a monographic study of the genus can clarify. Even in modern taxonomic and floristic treatments, one can sense this confusion and doubt. Schweinfurth (in Standley "Flora of Costa Rica" in Field Mus. Nat. Hist. Bot. Publ. 391 (1937) 245) followed what he thought to be Reichenbach's concept of the species as shown by his citation as basic material both the Oersted and the Wendland collections. Pertinent to this point, perhaps, is Schweinfurth's observation (loc. cit. 242) that he considered *Lepanthes Brenesii* Schltr. to be "very close to, if not the same as, *L. turialvae*." In 1946, L. O. Williams (in Woodson & Schery "Flora of Panama" in Ann. Mo. Bot. Gard. 33 (1946) 84) stated that "*Lepanthes turialvae*, as now delimited, is possibly an aggregate of several species." Extreme confusion marks the treatment of *Lepanthes turialvae* by Ames & Correll ("Orchids of Guatemala" in Fieldiana, Bot. 26 (1952) 196, 204). Their description is so very broad that it would embrace a number of species. Furthermore, there is a discrepancy between the characters used to key out *Lepanthes turialvae* (e.g. "Lip without a ciliate apicule or pubescent midlobe . . .") and the detailed description of the concept (e.g. lip "with a minute puberulent apicule in the sinus").

In view of this extreme confusion which, as we have seen, goes as far back as the original description, I suggest that the binomial *Lepanthes turialvae* Rchb. fil. be rejected as a *nomen confusum* in accordance with Articles 63 and 65 of the *International Code of*

[1] There is here a discrepancy between the French and the English versions. The French version (as well as the Spanish) uses the word "confusion" where the English (and the German: "Irrtum") employs "error": "Un nom est a réjèter . . . s'il est une source de confusion." Lanjouw has stated in the preface of the *International Code* . . . that "it was decided [by the Nomenclature Section] that, should there be any inconsistency between the versions, the English one would be regarded arbitrarily as correct."

Botanical Nomenclature as adopted at Paris in 1954: (Article 63) "A name must be rejected . . . if it is a source of error"[1] and (Article 65) "A name must be rejected if it is used in different senses and so has become a long-persistent source of error." It seems to me that no purpose would be served by trying to retain a name which apparently can never be clarified with satisfaction. However, in view of the fact that monographic studies in *Lepanthes* will shortly be initiated, I merely offer this as a suggestion and leave formal action to the monographer.

CHROMOSOME NUMBERS IN THE GENUS KRAMERIA: EVIDENCE FOR FAMILIAL STATUS

B. L. Turner

The genus *Krameria* is composed of about 20 species of perennial herbs and shrubs, most of which occupy the warmer desert or semi-desert regions of North and South America (Britton, 1930). Since its initial description in 1762 the genus has been a taxonomic "problem", both as to rank and phyletic position. Some workers have recognized it as the single genus of the family *Krameriaceae* (Chodat, 1890; Small, 1903; Britton, 1930; Abrams, 1944; Cronquist, 1957; etc.); other workers have assigned the genus subfamilial rank within the *Leguminosae* (Benson and Darrow, 1954; Benson, 1957); while still others have relegated the group to merely tribal status within the subfamily *Caesalpinioideae* of the *Leguminosae* (Taubert, 1894; Capitaine, 1912; etc.).

Such differing taxonomic treatments are not particularly disturbing since most of the workers mentioned above are more or less in agreement that the relationship of *Krameria* lies within or close to the *Leguminosae* and in particular to the tribe *Caesalpinioideae*. However, there are serious doubts as to its phyletic position. It is interesting to note that while such an eminent worker as Taubert in Engler and Prantl's PFLANZENFAMILIEN treats the genus as a tribe within the subfamily *Caesalpinioideae* of the order Rosales, Hutchinson (1926) places the genus in the family *Polygalaceae* of the order *Polygalales*, quite removed from the *Leguminosae* proper. Indeed, Taubert had enough confidence

in his treatment to relate *Krameria* specifically to the tribes *Cassieae* and *Eucaesalpinieae* and so placed *Krameria* as tribe 6 between these two taxa. Hutchinson does not give reasons for the inclusion of *Krameria* in the *Polygalaceae*, but precedence for such a treatment may be found in Bentham and Hooker (1862) who also placed it in the *Polygalaceae*. The latter authors, in treating this family, listed *Krameria* last among a group of "genera affinis aut exclusa, v. dubia." Hallier (1912) also viewed the relationship of *Krameria* as being with the *Polygalaceae* but assigned it familial status.

Kunz (1913) has given the most detailed study of the problem to date. After a review of the literature and as a result of his own observations on exomorphic and anatomical characteristics he concluded that *Krameria* did not belong within the *Caesalpinioideae* but rather should be treated as a distinct family. He did not attempt to show phyletic position, but he did indicate that *Krameria* was perhaps closer to the *Leguminosae* than the *Polygalaceae*.

Since Kunz's excellent study only a few published facts have been added. Heimsch (1942), using anatomical criteria, considered the position of *Krameria* with respect to the *Leguminosae* and *Polygalaceae*. He concluded that *Krameria*, on the basis of wood structure, was closer to the latter family. However, Erdtman (1944), on the basis of pollen morphology, briefly commented on the unnatural position of *Krameria* when placed in the *Polygalaceae* and stated that it belonged to the *Caesalpinioideae* of the *Leguminosae*. Dr. John Dwyer (personal communication), after a broad study of floral types within the *Caesalpinioideae*, has concluded that *Krameria* does not belong within this subfamily, though he has no set opinion of its phyletic position.

In the present paper chromosome evidence has been used to evaluate the position of *Krameria* with respect to the *Caesalpinioideae*. Unfortunately, chromosomal information is not adequate to permit comparisons with the supposed extra-leguminous relatives of *Krameria*, so little can be added to the controversy regarding phyletic position.

K. grayi and *K. ramosissima* are small shrubs of semi-desert and desert regions of North America, while *K. lanceolata* is a widespread, common perennial herb which occurs throughout the

Chromosome Numbers

Meiotic chromosome counts[1] were obtained for three species of *Krameria* as enumerated below:

Species	*Source*	*n*
Krameria grayi Rose & Painter	TEXAS, Terrell Co.: 10 mi. east Sanderson. *B.L.T. 3927*	6
Krameria lanceolata Torr.	TEXAS, Coryell Co.: 3 mi. north Cooperas Cove. *B.L.T. 3811*	6
" "	TEXAS, Kinney Co.: 12 mi. northeast Brackettville. *B.L.T. 3803*	6
" "	TEXAS, Leon Co.: Marquez Dome. *M. C. Johnston et al. 54994*	6
" "	TEXAS, Val Verde Co.: 10 mi. northwest Langtry. *B.L.T. 3771*	6
Krameria ramosissima (Gray) Wats.	TEXAS, Kinney Co.: 10 mi. southeast Brackettville. *B.L.T. 3874*	6

Southwestern United States and Mexico. All collections examined proved to be diploid with $n = 6$. Since the chromosomes in the first division of meiosis are exceptionally large, showing three or more chiasmata at metaphase (fig. 1), two-dimensional camera lucida drawings and photography become difficult.[2] Best counts are obtained from Division II of meiosis, when the chromosomes are less massive and thus flatten more easily. As indicated in figures 2 and 4, these chromosomes have nearly medium centromeres.

Discussion

Taubert in Engler and Prantl's PFLANZENFAMILIEN treated *Krameria* as the sole genus of the tribe *Kramerieae*, placing it after the tribe *Cassieae* of the *Caesalpinioideae*. By reference to floral morphology, Taubert (footnote, p. 166) explicitly reckoned its relationship to be with this latter tribe.

Since the inclusion of *Krameria* within the *Leguminosae* should depend upon the total similarities it shares with members of the *Caesalpinioideae*, it seems appropriate to examine the chromosomal evidence bearing on this presumed relationship. As indi-

[1] Buds were killed and fixed in a mixture of 4 chloroform: 3 absolute alcohol: 1 glacial acetic acid. Anthers were squashed in acetocarmine 3–14 days after collection. Voucher specimens are deposited in The University of Texas Herbarium, Austin, Texas.

[2] The meiotic chromosomes of *Krameria* rank among the largest known within the dicots. Covas and Schnack (1946) and Baldwin and Speese (1957) have documented somewhat larger meiotic chromosomes for two parasitic species of the Loranthaceae (*Psittacanthus cuneifolius* and *Phoradendron flavescens*). Except possibly for those of the well known species of *Paeonia* these species have the largest meiotic chromosomes of any dicot known to the present writer.

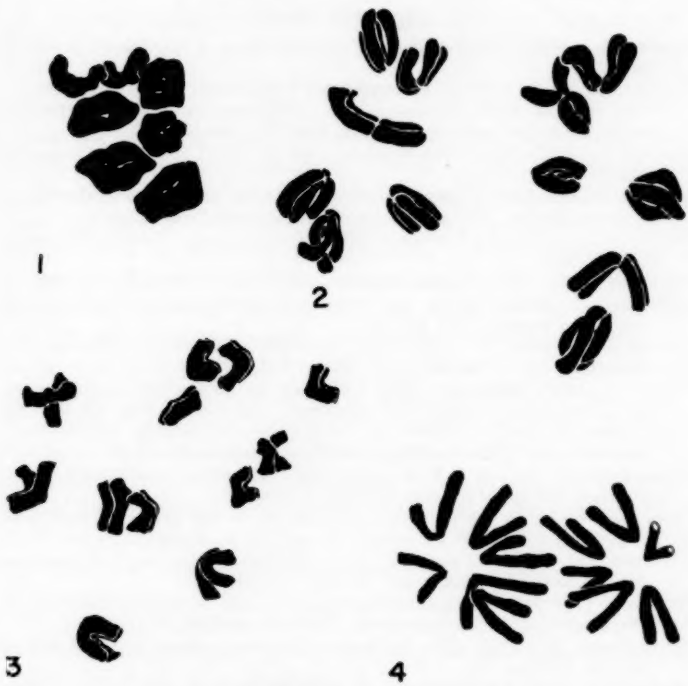
cated above, *Krameria* is, so far as known, unibasic with a number of $x = 6$, its meiotic chromosomes being especially noteworthy for their very large size and several chiasmata. A base number of $x = 6$ is not known for any of the tribes within the *Caesalpinioideae* (Darlington and Wylie, 1956).[3] However, since a base number of $x = 12$ is common for many genera of the *Caesalpinioideae* it might be conjectured that the number $x = 6$ for *Krameria* is but a lower base for the subfamily as a whole. Consideration of chromosome morphology proves more instructive. Meiotic chromosomes from a wide selection of *Cassia* species (Turner, 1956; H. S. Irwin, unpublished) are consistently small, usually showing only two terminalized chiasmata at metaphase. This is also true of the known meiotic chromosomes of species examined in the tribes *Bauhineae* and *Eucaesalpinieae*. By comparison, meiotic chromosomes of *Krameria* are 10–40 times as massive as those of the *Cassieae* thus far examined.

Unfortunately, *Krameria* can not be compared with the *Polygalaceae* since chromosomal information on the family is scanty. The only established base number for the family is $x = 7$ and this from a single *mitotic* count on *Bredemeyera colletioides* (Covas and Schnack, 1946).

Though the cytological evidence available at present does not permit one to judge phyletic alternatives, at least chromosomal comparisons of *Krameria* with members of the subfamily *Caesalpinioideae* seem to negate any close relationship with taxa of this group. In view of this negation, particularly as concerns its affinity with the *Cassieae*, the genus *Krameria*, even if related to the *Caesalpinioideae* on phyletic grounds, seems deserving of supra-tribal rank, if cytological evidence is considered along with that of wood anatomy, floral morphology, etc.

"Problem" taxa such as *Krameria* make present-day taxonomy the exciting field it is. One never knows how new evidence will affect the taxonomic scales. Indeed, it stimulates the taxonomist to look to other fields for additional weights that might affect the balance. Thus floral morphology, anatomy, palynology,

[3] These authors (p. 148) list 6 as one of several base numbers for *Cassia*, but this is not borne out by a reference to their listed counts. Senn (1938) gives a count of $n = 6$ for *Cercis canadensis*, but Baldwin (1939) reported counts of $2n = 14$ for several collections of the species. In view of the drawing accompanying Senn's report (p. 183), which appears to show two clumped chromosomes drawn as one, the report of $n = 6$ for this species should be considered erroneous.



Figures 1–4. Camera lucida drawings of the meiotic chromosomes in *Krameria* spp.—Fig. 1 *K. lanceolata*, chromosomes closely packed at metaphase I.—Fig. 2. *K. lanceolata*, metaphase of division II.—Fig. 3. *K. ramosissima*, metaphase of division II.—Fig. 4. *K. grayi*, anaphase of division II (only one half of quartet shown). (X ca 1400).

biochemistry, cytology, etc., must necessarily bring us closer to the truth, since the total attributes of a group of organisms will more nearly reflect their relationships than will the characters from any one field when considered alone.

If all taxonomic problems were obvious and merely resolved themselves to cataloguing always discreet, easily placed entities, then many of us would long since have lost interest in the tabulation and turned to other fields.

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A TAXONOMIC STUDY OF THE GENUS PHYSALIS IN NORTH AMERICA NORTH OF MEXICO[1]

U. T. Waterfall

Linnaeus founded the genus *Physalis* in 1753 with nine species, two of which are now usually referred to *Withania*. Five of the remaining seven are found within the area of the present study, although one, *P. Alkekengi,* is known only as a horticultural species, or as an escape from cultivation. In the second edition of Species Plantarum (1762) Linnaeus added two more species, *P. pensylvanica* and *P. peruviana*. The former does not occur in Pennsylvania and perhaps is not found in North America. In any event, it is considered to be a synonym of *P. viscosa*. *P. peruviana* is sometimes cultivated. Perhaps it escapes, but, if so, it is rarely collected. Pre-Linnean authors were familiar with the genus under the names *Physalis, Solanum* and *Alkekengi* as indicated in the Linnean references. Philip Miller (1768) described two species coming within the scope of this study. One of them, *P. virginiana,* is here interpreted as it has been for the last sixty years, although the application of the name is by no means certain.

Michaux (1803) described *P. lanceolata* and *P. obscura,* the latter consisting of var. *glabra* and var. *viscidopubescens*. Nees (1831) described *P. heterophylla, P. lanceifolia* and *P. Linkiana*.

P. crassifolia, the common species of southwestern desert regions, was described by Bentham (1844). Thomas Nuttall, in publications hereinafter enumerated under the species concerned,

[1] This paper is based on a dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at the University of Oklahoma under the guidance of Dr. George Goodman, Professor of Plant Sciences. The author is grateful to him, and to the other members of his committee, for their valuable suggestions.

He is also thankful to the curators of several herbaria whose loans of all, or selected parts, of their valuable collections of *Physalis* made this study possible. They have loaned 8000 sheets of *Physalis* and related genera. Of this total, there are 5716 sheets of *Physalis* included in the present study. Many of the remainder were collections from other areas which materially aided in the formation of species concepts. These herbaria, listed by the standardized abbreviations published by Lanjouw and Stafleau (1954), are: ARIZ, COLO, DUKE, GH, KANU, LL, MICH, MO, NY, OKL, OKLA, P, PH, RM, SMU, TEX, UARK, UC and WIS.

Thanks are also due the librarians of both the University of Oklahoma and Oklahoma State University (formerly Okla. A. & M. College) for securing photostats of publications unavailable locally, and the Arnold Arboretum of Harvard University for the loan of photographs of Linnean types, as well as to Dr. Albert Delisle formerly of the University of Notre Dame for photographing certain types of species described by Greene.

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described *P. angustifolia, P. longifolia, P. mollis, P. pumila* and *P. Walteri.* Dunal (1852) described *P. nyctaginea,* now generally referred to *P. heterophylla.*

In his study of the North American species, Asa Gray (1875) described *P. Fendleri, P. hederaefolia* and *P. Wrightii.* Rydberg (1896), in the last general study of the genus, described *P. ciliosa, P. comata, P. macrophysa, P. neomexicana, P. rotundata* and *P. versicolor.*

Following this, as a result of increased botanical activity, Mohr (1899) described *P. monticola*; *P. rigida* was described by Pollard and Ball (1900), and *P. polyphylla* by Greene (1900). *P. missouriensis* and *P. subglabrata* were proposed by Mackenzie and Bush (1902). Rydberg added *P. floridana, P. pendula* and *P. sinuata* in Small's Manual (1903). Aven Nelson (1909) proposed *Quincula lepidota* and *P. genucaulis. P. caudella,* described by Standley (1937) from Chihuahua has been found in southern Arizona, and these collections usually have been identified as *P. lanceolata.*

Margaret Y. Menzel (1951) has published an exploratory survey of the cytology and genetics of many of the species of our area, as they were interpreted by Rydberg, and various collectors who followed that author's treatment. Her work is valuable because it shows that the observed variation may indeed be correlated with cytologic and genetic differences.

Taxonomic Characteristics

The stability of taxonomic characteristics apparently has been much disturbed by the long-continued distribution of various species by man as esculents. Some of the species, such as *P. ixocarpa* and *P. peruviana,* are still so used. No doubt many of the species have been used by aborigines of many parts of the world at one time or another. This introduces the possibility of gene interchange between taxa that would otherwise not be contiguous. Furthermore, man's activities in producing disclimaxes provide habitats in which individual plants, or populations, of narrow ecological amplitude may survive. Such ecological niches might not have existed otherwise. It may be significant that many collections of *Physalis* are made in such disturbed habitats. Somewhat similar situations are admirably discussed by Edgar Anderson (1949).

The following discussion concerns the principal morphological characteristics which have been used in the taxonomy of the genus.

ROOTS. Both annual and perennial species occur in the genus. The former have fibrous root systems, or sometimes taproots. The latter are usually woody-based or rhizomatous. The annual vs. perennial characteristic has been used much in the past, beginning with Linneaus, to divide the genus into two main divisions. Since most herbarium specimens do not show the underground parts, this system is not a particularly convenient one. More dependence has been placed on other structures in the following treatment.

STEMS. All of our species have herbaceous stems, although in Mexico and Central America shrubby ones may occur. They may perennate from a woody caudex in such species as *P. crassifolia* of the desert areas of southwestern United States. Several of them grow from rhizomes, which may be cord-like, near the surface, and are often present in herbarium collections, as *P. arenicola* of sandy areas of Georgia and Florida, or thick, deeply buried and seldom collected, as the wide-ranging *P. heterophylla* and *P. virginiana*. The stems may be erect to prostrate and simple to much branched. An extreme in branching is found in *P. crassifolia* which, as reported by Jepson (1925), forms plants "1–3 ft. broad and ½–1 ft. high."

LEAVES. The leaf blades are usually ovate to ovate-lanceolate, but they may be reniform, as are rarely some of the lower leaves of *P. hederaefolia*, or narrowly linear as in *P. angustifolia*. Petioles may be longer than the blade, or the blades may taper into short, winged petioles. The leaves are normally alternate, but sometimes appear to be opposite as in *P. viscosa* var. *Elliottii* which often has two leaves at a node, particularly in the upper part of the stem.

Leaf shape has often been used as a basis for establishing, or characterizing, taxa, as is indicated by such names as *latifolia*, *hederaefolia*, *angustifolia*, *heterophylla*, *lanceifolia*, *integrifolia*, *crassifolia*, *spathulaefolia* and *longifolia*. No doubt in some instances, as in *P. angustifolia* with its long linear leaves, the emphasis on leaf-form is justified. However, the size, shape and margins of leaves are extremely variable characteristics in groups that appear to be natural populations. One approach to the

understanding of this variability is to study a species that is well-delimited otherwise. An excellent example is *P. lobata*, a species so distinct that it has been considered a separate genus by such taxonomists as Rafinesque and Rydberg. Here the leaf shape may vary from narrowly ovate to linear-oblong, and the margins from pinnatifid to entire. Although the variation in leaf margins appears to be at an extreme here, the variability of leaf shape can be duplicated, and the variability in margins approached, in several other natural populations.

Under such conditions it would seem hazardous to establish species or varieties based on these characteristics; such a procedure should be followed only when these features are correlated with other morphological characteristics, or with geographic distribution. The author has utilized these criteria in maintaining *P. viscosa* var. *spathulaefolia* of the Texas gulf, and *P. viscosa* var. *maritima* of the southeastern seacoast. Here the extremes are distinct, but variation makes some collections difficult to place. Measurements of many specimens show the leaves of the former to be narrower than the latter, as indicated later in the keys to the species. However, if these features are used with the idea of either matching specimens, or describing new species, only confusion can result.

VESTITURE. The indument varies from hairs that are stellate or variously branched, to long jointed hairs and short hairs, capitate or sessile glands, or small crystalline vesicles as in *P. lobata*. Even the seemingly glabrous species usually have a few trichomes of some kind, at least on the younger parts. Frequently two or more kinds of trichomes are intermixed.

Such names as *viscosa*, *mollis*, *comata*, *pubescens*, *hirsuta*, *cinerascens*, *ciliosa*, *villosa*, *pruinosa* and *subglabrata* indicate the consideration that authors have given to indument in the past. The procedure seems to be partly justified. Surely the "stellate" populations are related. But if one attempts to distinguish taxa on the basis of the density or the size of the stellate hairs, caution should be exercised. In this study *P. viscosa* var. *mollis* has been segregated from var. *cinerascens* partly by this characteristic, but the latter taxon is extremely variable within itself in this respect. In *P. heterophylla* many of the variations in vestiture seem to be so little correlated, either with other characteristics, or with

geographic distribution, as to be unusable to distinguish even varieties. On the other hand, in *P. virginiana*, *sens. lat.*, the correlations are such that they are of value in helping to establish geographic varieties. In the *P. angulata-P. pubescens* series indument is also of taxonomic significance, the villous *P. pubescens* usually having abundant multi-cellular hairs, *P. angulata* having a few short ones.

COROLLAS. The shape, color and spotting of the corollas have been considered of taxonomic significance. The shape varies from funnel-form-campanulate to rotate with the limb reflexed. The corolla is plicate, and is truncate with the exception of *P. Alkekengi* in which the lobes are separated by short sinuses. The shape of the corollas may be of taxonomic significance. Since the characteristic shape is attained for only a short time in the full sun, the application of this criterion is of limited value. Several species such as *P. lobata*, *P. Wrightii*, *P. hederaefolia* and *P. crassifolia* have corollas that are either rotate, or have a reflexed limb when fully open. Since the corollas are seldom fully open, the author has usually used a linear measurement for comparative purposes where such usage seemed desirable.

Color of the corolla has been used to help characterize *P. lobata*, which is our only species with a bluish, or violet, corolla. Otherwise the presence, and sometimes the color, of five spots on the limb of the yellowish corolla near its base has been found useful. The majority of the species either have distinct, dark spots present, or they have none that are noticeable in herbarium specimens. A few taxa such as *P. hederaefolia* var. *Fendleri* and some of the maritime varieties of *P. viscosa* have spots which are only a little darker than the rest of the corolla.

STAMENS. Size and color of the anthers are of taxonomic value. With a few exceptions, large anther size (measurements given in the keys) and thick filaments are correlated with our perennials. Small anther size and slender filaments are usually found in our annual species. In some taxa anther color is of significance. So many of the annual species have blue anthers that the yellow anthers of *P. missouriensis* attract attention. In others, such as *P. heterophylla* and *P. virginiana* var. *virginiana*, yellow or bluish tinged anthers seem to occur without much significance. However, *P. virginiana* var. *subglabrata* and var. *sonorae* may be dis-

tinguished by the bluish anthers of the former and the yellow anthers of the latter even when their other characteristics overlap.

A peculiarity of *P. crassifolia* and its var. *versicolor* is the presence of a few long jointed hairs on the filaments.

FLOWERING CALYX. The relative depth to which the calyx lobes are divided may be of value, as it is in helping to separate *P. angulata* var. *angulata* from var. *pendula*.

PEDUNCLE. The length of the peduncle, both flowering and fruiting, may be of taxonomic significance. In fruiting material of *P. ixocarpa* and *P. virginiana* var. *subglabrata*, some specimens of which may resemble each other, the very short fruiting peduncle of the former will serve to separate the two. Among the southwestern desert species, *P. hederaefolia* and its relatives may be separated from *P. crassifolia* and its relatives by the short flowering peduncle of the former. Although of lesser significance in the *P. angulata* complex, it may be used, in conjunction with the size of the fruiting calyx, to help separate *P. angulata* var. *angulata* from var. *pendula* and var. *lanceifolia*.

FRUITING CALYX. The calyx greatly enlarges with the maturing fruit, usually being much inflated around it. In some populations the size and shape seem to be constant, and characteristic enough to be taxonomically usable. In *P. pubescens* and its relatives there is present a distinctly five-angled fruiting calyx. A population in southern Arizona is proposed as a new species, easily recognized by its unusually broad, sharply-angled fruiting calyx. In the *P. angulata* series, *P. angulata* var. *angulata* has a larger fruiting calyx than either var. *pendula* or var. *lanceifolia*.

In other populations the size and shape of the fruiting calyx seem to be either quite variable, or the extremes occur sporadically. The present author believes that the large-calyx form described as *P. macrophysa* is a more or less sporadically occurring form of *P. virginiana* var. *subglabrata*, although it also may be found in intergrades with var. *sonorae* (*P. longifolia*). Specimens with large fruiting calyces also appear in *P. virginiana* var. *virginiana* and in some phases of *P. viscosa*.

The length of the lobes of the fruiting calyx was considered characteristic enough by Standley (l.c.) to call a new species *P. caudella*.

The writer has not found the indentation at the base of the

fruiting calyx to be of much taxonomic value. Considerable variation may occur on the same plant. Of course if the calyx is nearly filled by the berry, it will be little invaginated.

OTHER CHARACTERISTICS. The style has not been used to any extent. In *P. lobata* it is distinctively curved near the base and bent to one side. The more or less reniform, punctate to reticulate seeds are very similar in most of the species. Differences seen in preliminary study appear to be bridged by many intermediates when a large series is examined. The backs of the seed of *P. lobata* are rather crenate or rugose.

Generic Relationships

The genus *Physalis* is studied here in its more or less conventional conception, including those members of the *Solanaceae* having a funnelform or campanulate to rotate, or rotate-reflexed corolla, longitudinally dehiscing anthers, and a berry, or berry-like fruit, enclosed in an enlarged and usually inflated calyx. It excludes both *Margaranthus*, with its urceolate corollas and very *Physalis*-like fruiting calyces, and also *Chamaesaracha* with a corolla very similar to some species of *Physalis*, but with a fruit very closely invested by the enlarging calyx.

When not in flower, *Margaranthus* could hardly be distinguished from moderately small-fruited species of *Physalis*. The rather tightly investing fruiting calyx of *Chamaesaracha* can be matched, or is approached, in some specimens of certain species of *Physalis* such as *P. ixocarpa*. A peculiar situation is found in *Chamaesaracha* where *C. grandiflora*, originally described as *Physalis* by Hooker, and a related species, *C. nana*, have seeds very similar to the punctate or minutely reticulate seeds of *Physalis*, while the other species of the genus have rather strongly alveolate surfaces.

Possibly both genera should be included in *Physalis*. This would make *Physalis* an inclusive genus, similar in its concept to *Oenothera* as delimited by Munz and other conservative taxonomists. In that genus a number of subgenera, regarded as genera by some authors, are bound together by flower similarities despite their differently shaped fruits. In *Physalis*, under this broad concept, the distinctive fruiting calyx would hold together subgenera differing in corolla structure. In *Chamaesaracha* the dis-

tinctiveness of the fruiting calyx becomes progressively less evident. The difficulty here would be in finding a stopping place short of including the whole genus. The author prefers making a more intensive study of the problem before proceeding with such action.

Since there is the possibility of creating distinctive subgenera as outlined in the preceding paragraph, it seems preferable not to formally place the species here treated into subgenera or sections, but to defer this action until not only species of *Physalis* from other areas, but also related taxa can be studied.

Taxonomy

PHYSALIS L., Species Plantarum 1: 182. 1735; *Alkekengi* Tourn. ex Hall, Enum. Stirp. Helv. **2:** 508. 1742; *Herschellia* Bowdich, Excurs. Mader. 159. 1825. *Quincula* Raf. Atl. Journ. 145. 1832; *Alicabon* Raf., Sylva Tellur. 56. 1838; *Pentaphiltrum* Reichb., Das Herbarienbuch 121. 1841; *Boberella* Krause, in Sturm, Fl. Deutschl. ed. 2 (10): 54. 1903.

Plants annual or perennial with herbaceous stems, some having woody caudices, others with short to elongated rhizomes; leaves usually broadly ovate to linear, alternate or sometimes two at a node; vestiture various in kind and quantity, including short hairs, long jointed hairs, stipitate or sessile glands, or with hairs variously branched to stellate; corollas plicate, campanulate to rotate with the limb reflexed; corolla color usually some shade of yellow with, or without, five darker spots near the base of its limb, sometimes blue; flowers usually solitary in the axils of the leaves, sometimes on foreshortened axillary branches causing them to appear to be in axillary fascicles; calyx united, its lobes distinct for a little over one-half to about one-fourth of its length; calyx lobes ovate-deltoid to narrowly lanceolate, sometimes acuminate; calyx enlarging with, and usually inflated around, the maturing fruit; fruit a two-carpellate many- to few-seeded berry, sometimes rather dry; style more or less filiform, usually expanding somewhat at its summit into a slightly capitate, but sometimes nearly truncate, stigma; stamens five, their filaments attached near the base of the corolla tube; anthers ovate-oblong to linear-oblong, dehiscing by lateral slits, yellow or bluish in color; filaments varying from nearly as wide as the anthers, and sometimes clavate, to slender and filiform.

(*To be continued*)

New Illinois Carex Records.[1]—Collections of the following species of Carex have been deposited, as indicated, in Illinois State Museum (SM), University of Illinois (IU), University of Wisconsin (WU), and Rockford College (RC), herbaria.

Carex stenophylla Wahl. var. *enervis* (C. H. May) Kükenth. (*C. eleocharis* Bailey) ranges normally west and northwest from Iowa. It has not been reported east of the Mississippi River. In the spring of 1957 it was found on a dry gravel bluff prairie in Greater Rockford Airport south of Rockford, Winnebago County, in an area that was a part of Camp Grant during World Wars I and II. Here it grows in nearly pure stands in several patches 10 to 20 feet in diameter, blooming at the same time as *C. pensylvanica* Lam. var. *digyna* Boeckl. with which it is associated. It ceases growth by the first of July at which time the slender rhizomes and stolons have reached a length of 2½ to 3 inches. Thus it seems likely that seeding took place during World War I. Collection numbers are: *57–9* (SM, IU, WU, RC); *57–68* (SM, IU, RC); *57–157* (SM, IU, WU, RC); *57–248* (SM, IU).

Carex praegracilis W. Boott, another western species, is credited in the manuals to northern Michigan. There are no other records of its occurrence east of the Mississippi River. In 1951, it was found at Greater Rockford Airport and since then in a number of places on the gravel bluff prairie in the area, on a roadside near Perryville six miles from the Airport and in DeKalb County near Kirkland on a railroad right-of-way, 15 miles distant. Neither of these places are on a direct line of travel from the Airport. All are in prairie situations. The strong rhizomes grow rapidly but definite patches are not formed so the probable length of time that it has been established cannot be determined. The World War I idea of introduction would not apply to the DeKalb County station. Station locations and collection numbers are: Winnebago County; (Rockford Airport) *51–114* (SM); *52–356* (SM); *55–420* (WU); *57–158* (IU); (Perryville) *55–440* (WU, RC); *56–73* (IU). DeKalb County (Kirkland) *53–371* (SM); *55–141* (WU); *56–91* (IU).

In this location these plants bear seed sparingly but *C. praegracilis* is well dispersed and seems to be well established. *C. stenophylla* has persisted for 40 years and has spread. It is in a favorable habitat which is of a type common in Winnebago County. The airport authorities have agreed that this gravel hill

[1] A contribution from the Evelyn I. Fernald Memorial Herbarium of Rockford College.

prairie will not be disturbed unless it is needed for an essential operation of the airport, which is not likely. For these reasons it seems probable that these carices will become a part of our flora with *Paspalum stramineum, Ratibida columnifera, Froelichia gracilis, Artemisia dracunculoides*, and others from the west which are found in the same area.—Egbert W. Fell.

Nelumbo lutea in Essex County, Massachusetts.—The only known station for *Nelumbo lutea* (Willd.) Pers. in Essex County was the Devil's Dishfull in West Peabody where it was apparently introduced at some time between 1880 and 1913. It soon became so abundant that the pond became known as Lotus Pond and some well-intentioned but misinformed person erected a sign stating that the pond was the only place in the United States where the Sacred Lotus occurred. *Nelumbo* was still common there in the fall of 1953, when I collected a specimen. In August, 1957, I put my boat in the pond and covered the area thoroughly collecting aquatic plants. While *Nuphar variegatum* and *Nymphaea odorata* were as common as in the past there was no trace of *Nelumbo.* I can think of no valid cause to explain its disappearance.—Stuart K. Harris, dept. of biology, boston university.

Cabomba caroliniana in Essex County, Massachusetts.—When collecting aquatics in Fosters Pond, Andover, Massachusetts in June, 1957, I found that the most common plant there was *Cabomba caroliniana* Gray. This is the first station known in Essex County. Since Professor A. S. Pease, who has an uncanny ability to spot interesting plants, collected on the pond in 1903 and did not find *Cabomba,* it seems safe to assume that it must have been introduced there since that date. Probably *Cabomba* is more widely introduced in Massachusetts than collections indicate. There are only two sheets in the herbarium of the New England Botanical Club from this state other than my collection, 24 June 1957, *12997*. However, *Cabomba* is abundant in Muddy River in Boston's Fenway but no specimen appears in the Club herbarium.—Stuart K. Harris, dept. of biology, boston university.

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